UCRL-JC-124004 Abs

Extended Synopsis for 16th IAEA Fusion Energy Conference, Montreal, 1996

PROGRESS ON THE PHYSICS OF IGNITION FOR RADIATION DRIVEN INERTIAL CONFINEMENT FUSION (ICF) TARGETS*

John D. Lindl
Lawrence Livermore National Laboratory, Livermore, California, USA

The ignition threshold for radiation driven ICF targets is governed by the limitations imposed by laser-plasma interactions, which affect the peak driving flux and symmetry of x-rays in hohlraums, and by the growth of hydrodynamic instabilities in the imploding shell containing the fusion fuel, which sets a minimum on the required driving pressure (or radiation flux).

In experiments on the Nova laser during the past year, there has been major progress in quantifying the benefits of beam smoothing in reducing stimulated scattering processes and laser beam filamentation under conditions proposed for ignition targets on the National Ignition Facility (NIF). Hohlraums filled with a low density of low-z gas are the baseline targets for the NIF. Use of SSD (smoothing by spectral dispersion) with 2–3 Å of bandwidth results in <4–5% of Stimulated Raman Scattering (SRS) and less than about 1% Stimulated Brillouin Scattering (SBS) for intensities less than about $2x10^{15}$ W/cm^2 for this type of hohlraum. Although full scale NIF hohlraums cannot be tested on Nova, these results have been obtained by a combination of gas-filled targets which mock up the low-z regions, and by standard scale Nova hohlraums which mock up the high-z hohlraum wall of NIF targets. The symmetry in gas-filled hohlraums is also affected by the gas fill. A large body of evidence now exists which indicates that this is due to effects of laser beam filamentation. Single beam experiments on Nova have shown that these effects of filamentation can be largely controlled by beam smoothing. A modification is being implemented to demonstrate this control with all ten of Nova’s beams.

There has also been major progress in the use of three dimensional (3D) numerical models in quantifying the results of implosion experiments with and without deliberately perturbed initial capsule surfaces. Using capsules whose surface is modified by laser ablation to contain a specified perturbation, Nova experiments have been used to quantify the degradation of implosions subject to near NIF levels of hydrodynamic instability. Because of the relatively small number of beams on Nova, and because of long wavelength capsule wall thickness variations, these implosions are highly 3D. A new computer code called HYDRA, has been able to reproduce the results of these implosions when all sources of perturbations are incorporated. A technique has also been identified for modifying the Nova beam irradiation geometry to make Nova hohlraums more closely resemble the NIF geometry. This modification should result in implosions which are less affected by x-ray flux nonuniformities.

In addition to the work on Nova, much more extensive modeling of proposed NIF ignition targets has resulted in a variety of targets using different materials in the fuel shell, using driving temperatures which range from 250–300 eV, and requiring energies which range from less than 1 MJ up to the full 1.8 MJ design capability of the NIF. Recent experiments on Nova have shown that hohlraum walls composed of a mixture of high-z

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

materials have reduced x-ray losses. The mixture of materials is chosen so that regions of photon energy with high opacity in one material overlap regions of low opacity in another material. These “cocktail” mixtures of materials result in targets which require about 20% less laser energy for a given size fuel capsule.

All of these advances taken together have resulted in a recommendation by the ICFAC, the U.S. Department of Energy (DOE) advisory board on ICF, that DOE complete preliminary engineering design and move ahead with detailed engineering design of the NIF.